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TOPOLOGICAL NAGENDRAM Γ-SEMI SUB NEAR-FIELD SPACES OF A Γ-NEAR-FIELD SPACE OVER NEAR-FIELD

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ABSTRACT

In this paper it comprises four sections, In depth study makes me section 1 to introduce the Topological Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field, further author investigate the related properties in section 2 of Simply Connected Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field, in section 3 The exponential map Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field and finally in section 4 about Naturality of exponential map Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field.

Keywords: *Γ-near-field space; Γ-Semi sub near-field space of Γ-near-field space; Semi near-field space of Γ-near-field space, Left Invariant vector Γ-semi sub near-field spaces, Nagendram Γ-semi sub near-field space Homomorphisms, Topological Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field.*

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SECTION-1:

1.1 Topological Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field.

Definition 1.1.1: A topological Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field N is a topological Nagendram Γ-near-field space which is a near-field space over a near-field and has the properties that the Nagendram Γ-semi sub near-field space operations are continuous.

Lemma 1.1.2: Let N be a connected topological Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field. Suppose H is an abstract open Nagendram Γ-semi sub near-field space of N. Then H = N.

Proof: For any $a \in N$, $L_a : N \rightarrow N$ given by $g \mapsto ag$ is a homeomorphism. Thus for each $a \in N$, $aH \subseteq N$ is open. Since the Nagendram Γ-semi co-sub near-field spaces partition N and N is connected. We must have $|N/H| = 1$. This completes the proof of the lemma.

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Lemma 1.1.3: Let N be a connected topological Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field, U ⊆ N a neighbourhood of 1. Then U generates N.

Proof: For a Nagendram Γ-semi sub near-field space W ⊆ N, write $W^{-1} = \{g^{-1} \in N \,/\, g \in W\}$. Also, if k is a positive integer, we set $W^k = \{a_1, a_2\ldots.., a_k \,/\, a_k \in W\}$. Let U be as above, and $V = U \cap U^{-1}$. Then, V is open and $v \in V$ implies that $v^{-1} \in V$. Let $H = \bigcup_{n=1}^{\infty} V^n$. Then, H is a Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field and we claim that H is open. Notice that H is precisely the Γ-semi sub near-field space generated by U. So if we prove that H is open, then H = N and the lemma is proved.

If V^k is open, then $V^{k+1} = \bigcup_{a \in V}^{\infty} (aV^k)$ is open and since left multiplication is a homeomorphism. By induction, V^n is open for every n. Thus H is open. This completes the proof of the lemma.

We will use these results to prove that Nagendram Γ-semi sub near-field space sub algebras correspond to connected Nagendram Γ-semi sub near-field spaces. But first, we will need to develop some more terminology and recall some results differential geometry.

Definition 1.1.4: A d-dimensional distribution D on a manifold M is a sub-bundle of TM of rank d.

Note 1.1.5: Given a distribution $D \subseteq TM$, does there exist for each x ∈ M an immersed sub-manifold L(x) of M such that $T_yL(x) = D_y$ for every $y \in L(x)$? A necessary condition for this question to be answered in the affirmative is X, Y ∈Γ(D) then [X, Y] ∈ Γ(D).

Definition 1.1.6: A distribution D on a manifold M is integrable or involutive if for every X, Y ∈Γ(D) , [X, Y] ∈Γ(D). An immersed sub manifold $L \subseteq M$ is an integral manifold of D if $T_xL = D_x$ for every $x \in L$.

We will get some mileage out of the following theorem and proposition for which we omit the proofs.

Note 1.1.7: Let D be a d-dimensional integrable distribution on a manifold M. Then, for all x ∈ M, there exists a unique maximal, connected, immersed integral sub -manifold L(x) of D passing through x.

Proposition 1.1.8: Suppose $D \subseteq TM$ is an integrable distribution and L ⊆ M is an immersed sub manifold such that $T_gL = D_y$ for every y ∈ L. Suppose $f : E \to M$ is a smooth map of manifolds and F(E) ⊆ L. Then, $f : E \to L$ is C^∞.

Theorem 1.1.9: Let N be a Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field with Nagendram Γ-semi sub near-field space algebras g and $h \subseteq g$ a Nagendram Γ-semi sub near-field space sub-algebras H of N with $T_1H = h$.

Proof: Consider $D \subseteq TN$ and given by $D_a = dL_a(h)$ for a ∈ N. Then, D is a distribution. We claim D is integrable. To prove this, let $v_1, v_2,\ldots\ldots,v_k$ be a basis of h. Let $V_1, V_2,\ldots..,V_k$ be the corresponding left invariant vector Nagendram Γ-semi sub near-field spaces on N. Then, $\{ V_1(g),\ldots\ldots..,V_k(g) \}$is a basis of D_g. Also, we have $[V_1(g),\ldots\ldots,V_k(g)] = dL_g([V_i, V_j](g))$ since the bracket of left invariant vector Nagendram Γ-semi sub near-field spaces is left invariant.

Now, for arbitrary sections X, Y of D, write them locally as $X = \sum_i x_i V_i$, $Y = \sum_j y_j V_j$ where $x_i, y_j \in C^\infty(N)$ ∀ i, j. So, $[X, Y] = \sum_{i,j} x_i V_i(y_j) V_j + \sum_{i,j} i, j x_i\, y_j [V_i, V_j] - \sum_{i,j} V_j(x_i) y_j V_i$ each term of which is in Γ(D) , and hence [X, Y] ∈ Γ(D).

We now get an immersed, connected, maximal sub manifold H of N such that $1 \in H$ and $T_1H = h$. The claim is that H is a Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field of N. To show that H is a Γ-semi sub near-field space of a Γ-near-field space, fix some $x \in H$. consider $x^{-1}H=L_x^{-1}$ (H). Then, $1=xx^{-1}\in x^{-1}H$ and for all $a \in N$, we have $T_{x^{-1}a}(x^{-1}H)=dL_x^{-1}\ (T_aH)= dL_x^{-1}\ (dL_a h) = dL_x^{-1}\ dL_{x^{-1}a} h = D_{x^{-1}a}$.

So, $x^{-1}H$ is a tangent Γ-semi sub near-field space to *D.* Since H is connected, $x^{-1}H$ is connected and by maximality and uniqueness of H, we have $x^{-1}H \subseteq H$. Therefore, H is a Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field of N.

Finally, we need to show that $m|HxH$ and $inv|_H$ are C^∞. But, $m : H\ X\ H \to N$ is C^∞ and $m\ (H\ X\ H) \subseteq H$. Therefore, multiplication is a smooth binary operation on H. Similarly, *inv* is smooth on H and thus H is a Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field of N. This completes the proof of the theorem.

SECTION-2:

2.1 Simply Connected Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field Introduction.

If $\rho : N \to H$ is a Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field morphisms, then $\delta\rho : g \to h$ is a map of Nagendram Γ-semi sub near-field space algebras. Is the converse true? i.e. if N, H are Nagendram Γ-semi sub near-field spaces with Nagendram Γ-semi sub near-field space algebras g and h respectively and $r : g \to h$ is a map of Nagendram Γ-semi sub near-field space algebras. Does not there exist a Nagendram Γ-semi sub near-field space morphism $\rho : N \to H$ with $\delta\rho = r$? Unfortunately, the answer is not always. We can answer affirmatively when N is connected and simply connected however. Let's recall a couple of definitions from basic topology.

Definition 2.1.1: A connected topological Γ-semi sub near-field spaces of a Γ-near-field space over near-field S is simply connected if S is arc-wise connected and every pointed map $f : (T^1, 1) \to (S, *)$ is homotopically trivial.

Definition 2.1.2: A continuous map $\rho : X \to Y$ is a covering map if for each $y \in Y$, there exists a neighbourhood U of y such that $\rho^{-1}U = \coprod U_\alpha$ where $U_\alpha \subseteq X$ is open for each α and $\rho/\ U_\alpha$ is a homeomorphism.

Lemma 2.1.3: Let, $\phi : A \to B$ be a map of Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field with $(d\phi)_1 = a \to b$ an isomorphism. Then (i) ϕ is a local diffeomorphism and (ii) If B is connected, ϕ is onto.

Proof: Consider the following commutative diagram

$$\begin{tikzcd} \mathbf{A} \arrow[r, "\phi"] \arrow[d, "L_a"'] & \mathbf{B} \arrow[d, "L_{\phi(a)}"] \\ \mathbf{A} \arrow[r, "\phi"'] & \mathbf{B} \end{tikzcd}$$

which can be viewed element-wise

$$\begin{tikzcd} \mathbf{I_A} \arrow[r, "\phi"] \arrow[d, "L_a"'] & \mathbf{I_B} \arrow[d, "L_{\phi(a)}"] \\ \mathbf{a} \arrow[r, "\phi"'] & \boldsymbol{\phi(a)} \end{tikzcd}$$

From this we can conclude that $(a\phi)_1=(dL_{\phi(a)})_{\phi(a)}^{-1}$ o $(d\phi)_a$ o $(dL_a)_1$. Now since $(d\phi)_1$ is an isomorphism. $(d\phi)_a$ is an isomorphism for every a ∈ A. Invoking the inverse function theorem. We see then that ϕ is a local diffeomorphism. In particular, ϕ is an open map, so ϕ(A) is an open Γ-semi sub near-field spaces of a Γ-near-field space over near-field of B. Now, if B is connected then ϕ(A) = B and thus ϕ is onto. This completes the proof of the lemma.

Lemma 2.1.4: Let ϕ : A → B be a surjective Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field map that is a local diffeomorphism. Then, ϕ is a covering map.

Proof: Let Λ = ker ϕ. Since ϕ is alocal diffeomorphism, there exists an open neighbourhood U of I_A such that $\phi|_U$ is injective and so U ∩ A = I_A. Since A is a Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field, the multiplication map m : A X A → A is continuous and so there exists an open neighbourhood V of I_A such that m(V X V) ⊆ U. That is, VV ⊆ U. Let W = V ∩ V^{-1}, then WW^{-1} ⊆ U. We claim that for every λ, λ′ ∈ A. λW ∩ λ′W = ϕ if and only if λ ≠ λ′.

To prove this claim, suppose λW ∩ λ′W = ϕ for some λ, λ′ ∈ A. Then, there exists w, w′ ∈ W so that λW = λ′W. But then , $(\lambda')^{-1}\lambda = 1$.
Now, what we have just proved is that ker ϕ = Λ is discrete, so $\phi^{-1}(\phi(W))$ = AW = $\prod_{\lambda \in \Lambda} \lambda W$ and we have a homeomorphism $\phi|_{\lambda W}$: λW ↦ ϕ(w). Thus, for each b ∈ B and a ∈ ϕ^{-1} (b), ϕ^{-1} (bϕ(W)) = $\prod_{\lambda \in \Lambda} a\lambda W$. Therefore, the fibers of ϕ are discrete and ϕ : A → B is a covering map. This completes the proof of the lemma.

We have the following fact from topology stated here as lemma:

Lemma 2.1.5: Let ϕ : A → B be a covering map of topological near-field spaces with B simply connected. Then, ϕ is a homeomorphism.

Lemma 2.1.6: Let N be a connected and simply connected Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field with Nagendram Γ-semi sub near-field space algebras g and H a Nagendram Γ-semi sub near-field space with Nagendram Γ-semi sub near-field space algebras h. Given Nagendram Γ-semi sub near-field space algebras morphism$r$: g → h, there exists a unique Nagendram Γ-semi sub near-field space morphism ρ : N → H such that δρ = r.

Proof: Let us first note that graph(r) = {(X, r(X)) ∈ g x h | $X \in g$ } is a sub Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field algebras of g x h since [(X_1, $r(X_1)$), (X_2, $r(X_2)$)] = (|X_1, X_2|, |$r(X_1)$, $r(X_2)$|) = (|X_1, X_2|, r|X_1, X_2|)

Therefore there exists a connected Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field Γ of N X H so that $T_1\Gamma$ = graph(r). The claim is that Γ is the graph of the Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field morphism ρ we are trying to construct, and hence it is sufficient to show that Γ is in fact a graph. Finally, if Γ is a graph, then we have

$$\begin{tikzcd} & N\ X\ H \arrow[ddl, "\pi_1"'] \arrow[ddr, "\pi_2"] & \\ & \Gamma \arrow[u] \arrow[dl, "\pi_1|r"'] \arrow[dr, "\pi_2|r"] & \\ N & & H \end{tikzcd}$$

And can simply define $\rho = \pi_2 \circ (\pi_{1|}r)^{-1}$. Now $(d\pi_{1|}r)_{(1,1)}$: graph(r) $\rightarrow g$ is an isomorphism. So $\pi_{1|}r$ is a local diffeomorphism and evidently $\pi_{1|}r : \Gamma \rightarrow N$ is a surjective Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field homomorphism. $\pi_{1|}r$ is a covering map. Since N is simply connected, $\pi_{1|}r$ is a homeomorphism.

Finally, define, $\rho : N \rightarrow H$ by $\rho = \pi_2 \circ (\pi_{1|}r)^{-1}$. Since Γ is a semi sub near-field spaces of a Γ-near-field space over near-field, ρ is a homomorphism and graph (ρ) = Γ. This gives us the Nagendram Γ-semi sub near-field space morphism we want.

We now have to establish the uniqueness of such a Nagendram Γ-semi sub near-field space homomorphism. Suppose $\overline{\rho} : N \rightarrow H$ is another such Nagendram Γ-semi sub near-field space morphism, then $S_{(1,1)}$ (graph($\overline{\rho}$)) = graph(r) = $S_{(1,1)}$(graph(ρ)).

Since graph($\overline{\rho}$) and graph(ρ) are connected Γ-semi sub near-field spaces of N × H with the same Nagendram Γ-semi sub near-field space algebras, they must be identical. Therefore, $\overline{\rho} = \rho$ and there exists a unique Nagendram Γ-semi sub near-field space morphism $\rho : N \rightarrow H$ such that $\delta\rho = r$. This completes the proof of the lemma.

SECTION-3: The exponential map Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field

3.1.1 The exponential Map. Given a Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field and its Nagendram Γ-semi sub near-field space algebras ***g***, we would like to construct an exponential map from ***g*** → N, which will help to give some information about the structure of ***g***.

3.1.2 Definition: exponential map. Let N be a Nagendram Γ-semi sub near-field space with Nagendram Γ-semi sub near-field space algebras ***g***. Define the exponential map exp : ***g*** → N by $\exp(X) = \gamma X(1)$.

Proposition 3.1.3: Let N be a Nagendram Γ-semi sub near-field space with Nagendram Γ-semi sub near-field space algebras ***g***. then for each X ∈ ***g*****,** there exists a map $\gamma X : N \rightarrow N$ satisfying

(a) $\gamma X(0) = I_N$,

(b) $\left.\frac{d}{dt}\right|_{t=0} \gamma X(t) = X$ and

(c) $\gamma X(s+t) = \gamma X(s)\gamma X(t)$.

Proof: Consider the Nagendram Γ-semi sub near-field space algebras map $\tau : N \rightarrow$ ***g*** defined by $\tau: t \mapsto tX$ for all X ∈ ***g***. Now, N is connected and simply connected Γ-semi sub near-field space, so there exists a unique Nagendram Γ-semi sub near-field space map $\gamma X : N \rightarrow N$ such that $(d\gamma X)_0 = \tau$ which is to say $\left.\frac{d}{dt}\right|_{t=0} \gamma X(t) = X$. This completes the proof of the proposition.

Lemma 3.1.4: Let N be a Nagendram Γ-semi sub near-field space with Nagendram Γ-semi sub near-field space algebras ***g***. Write $\hat{X}$ for the left invariant Γ-semi sub near-field space on ***g*** with $\hat{X}$ (1) = X. then, $\phi_t(a) = a\gamma X(t)$ is the flow of $\hat{X}$. In particular, $\hat{X}$ is complete Γ-semi sub near-field space with Nagendram Γ-semi sub near-field space algebras ***g***. i.e. the flow exists for all t ∈ N.

Proof: For a ∈ N, we have

$$\left.\frac{d}{dt}\right|_{t=0} a\,\gamma X(t) = (dL_a)_{\gamma X(s)}\left(\left.\frac{d}{dt}\right|_{t=0} \gamma X(t)\right) = (dL_a)_{\gamma X(s)}\left(\left.\frac{d}{dt}\right|_{t=0} \gamma X(t+s)\right)\Big)$$

$$= (dL_a)_{\gamma X(s)\gamma X(s)}\left(\left.\frac{d}{dt}\right|_{t=0} \gamma X(s)\gamma X(t)\right) = (dL_a)_{\gamma X(s)}\left(\left.\frac{d}{dt}\right|_{t=0} L\quad(\gamma X(t)\right)\Big)$$

$$= (dL_a)_{\gamma X(s)}\left(\left.\frac{d}{dt}\right|_{t=0} \gamma X(t)\right) = \left(dL_a\gamma X(s)\right)_1(X) = X(a\gamma X(s)\Big)$$

Since $\hat{X}$ is left invariant Γ-semi sub near-field space on ***g*** with $\hat{X}$ (1) = X. So, aγX(t) is the flow of $\hat{X}$ and exists for all t. This completes the proof of the lemma.

Lemma 3.1.5: The exponential Map is C^∞.

Proof: Consider the vector Γ-semi sub near-field space V on N × ***g*** given by V(a, X) = (dL_a(X), 0). Then V ∈ C^∞(N, ***g***) and the claim is that the flow of V is given by ψ_t(***g***, X) = (***g***γX(t),X). To prove this claim, consider the following:

$\left.\frac{d}{dt}\right|_{t=0} (g\gamma X(t),\ X) = (dL_{g\gamma X(s)}(X),\ 0) = V(g\gamma X(s), X)$ from which we can conclude that γX depends smoothly on X.

Now, we note that the map ϕ : N × N × ***g*** defined by ϕ(t, a, X) = (aγX(t),X) is smooth. Thus, if π_1: N × ***g*** → N is projection on the first factor, (π_1) ₒ (I_N, X) = γX(1) = exp(X) is C^∞. This completes the proof of the lemma.

Lemma 3.1.6: For all X ∈ ***g*** and for all t ∈ N γtX(1) = γX(t).

Proof: The intent is to prove that for all s ∈ N, γtX(s) = γ(ts). Now, s ↦ γtX(s) is the integral curve of the left invariant vector Γ-semi sub near-field space t$\hat{X}$ through I_N. But, t$\hat{X}$ = t$\hat{X}$, so if we prove that γX(ts) is an integral curve of t$\hat{X}$ through I_N by uniqueness the lemma will be established.
To prove this, first let σ (s) = γX(ts). Then σ(0) = γX(0) = I_N. we also have $\frac{d}{ds}\sigma(s) = \frac{d}{ds}\gamma X(ts) = d\left.\frac{d}{du}\right|_{u=ts} \gamma X(u) = t\overline{X}(\gamma X(ts)) = t\overline{X}(\sigma(s))$. So σ(s) is also an integral curve of $t\hat{X}$ through I_N. thus, γtX(s) = γX(ts) and in particular, when s = 1 we have γtX(1) = γX(t). This completes the proof of the lemma.

Note 3.1.7: Now we will use this lemma to prove a rather than nice fact about the exponential map.

Proposition 3.1.8: Let N be a Nagendram Γ-semi sub near-field space with Nagendram Γ-semi sub near-field space algebras ***g***. Identify both T_0***g*** and T_1N with ***g***. Then, $(d\ \exp)_0 : T_0\boldsymbol{g} \to T_1N$ is the identity map.

Proof: We have $(d\ \exp)_0$ (X) = $\left.\frac{d}{dt}\right|_{t=0} \exp(0+tX) = \frac{d}{ds}{}_{t=0}\gamma\, t\,X(1) = \left.\frac{d}{ds}\right|_{t=0}\gamma\, X(t) = X$. This completes the proof of the proposition.

Corollary 3.1.9: For all t_1, t_2 ∈ N, (i) exp((t_1 + t_2)X) = exp t_1X + exp t_2 (ii) exp(-tX) = $(\exp(tX))^{-1}$.

SECTION-4:

4.1 Naturality of exponential map Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field

4.1.1 Naturality of exponential map.

In this chapter, we reveal a property that will be used liberally in discussions to come and provide an important relationship between morphisms of Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field and morphisms of Nagendram Γ-semi sub near-field space algebras.

Theorem 4.1.2: Let $\phi : K \rightarrow N$ be a morphism of Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field. Then, the following diagram commutes:

$$\begin{tikzcd} \boldsymbol{k} \arrow[r, "\delta\phi"] \arrow[d, "\exp"'] & \boldsymbol{g} \arrow[d, "\exp"] \\ K \arrow[r, "\phi"'] & N \end{tikzcd}$$

That is to say, exp is natural.

Proof: Fix $X \in \boldsymbol{g}$. consider the curves $\sigma(t) = \phi(\exp(tX))$, $r(t) = \exp(\delta\phi(tX))$

Now, $\sigma, \tau: N \rightarrow N$ are Nagendram Γ-semi sub near-field space homomorphisms with $\sigma(0) = \tau(0) = 1$.

So, $\left.\frac{d}{dt}\right|_{t=0} \sigma(t) = (d\phi)_1 (\left.\frac{d}{dt}\right|_{t=0} \exp(tX)) = (\delta\phi)(X) = \left.\frac{d}{dt}\right|_{t=0} \tau(t)$.

So, $\sigma(t) = r(t)$ for all t. This completes the proof of the theorem.

Corollary 4.1.3: Let $K \subseteq N$ be a Nagendram Γ-semi sub near-field space of a of a Γ-near-field space over near-field N. Then, for all $X \in \boldsymbol{k}$, $\exp_N(X) = \exp_K(X)$. in particular, $X \in \boldsymbol{k}$ if and only if (IFF) $\exp(tX) \in \boldsymbol{k}$ for all t.

Theorem 4.1.4: Every connected Nagendram Γ-semi sub near-field space N is a quotient $\hat{M}/N$ where $\hat{M}$ is a simply connected Nagendram Γ-semi sub near-field space of the same dimension as M and N is a central discrete normal Γ-semi sub near-field space of $\hat{M}$. Both $\hat{M}$ and N are unique up to isomorphism.

Proof: Recall the universal covering space of a topological space is the unique up to desk isomorphism simply connected covering space. We will use, but not prove, the fact that every connected Nagendram Γ-semi sub near-field space has a universal covering space.

Let $\hat{M}$ be the universal covering space of M and denote by p the covering map. Let $\hat{I} = p^{-1}(1)$. Denote by $\hat{m}$ the lift of the multiplication map $m : M \times M \rightarrow M$ to $\hat{M}$ uniquely determined by $\hat{m}(\hat{I}, \hat{I}) = \hat{I}$. Similarly, inv : $M \rightarrow M$ lifts to $\hat{M}$ as well. Thus, $\hat{M}$ is a Nagendram Γ-semi sub near-field space of a of a Γ-near-field space over near-field N. p is a Nagendram Γ-semi sub near-field space of a of a Γ-near-field space over near-field homomorphism by definition of $\hat{m}$: $p(\hat{m}(a, b)) = m(p(a), p(b))$. Now, kernels of covering maps are discrete, and evidently, $M \cong \hat{M}$ / ker. p.

It remains to prove that N = ker. p is central, that is for all $g \in \hat{M}$ and $n \in N$, $gng^{-1} = n$.

Fix $n \in N$. Define $\phi : \hat{M} \rightarrow \hat{M}$ by $\phi(g) = gng^{-1}$. Since N is Γ-semi normal sub near-field space $\phi(M) \subseteq N$. Now $\hat{M}$ is connected so $\phi(M)$ is connected since is continuous. But, N is discrete so $\phi(M)$ is a single point. We have $\phi(1) = n$ and hence $\phi(M) = n$. therefore, N is central. This completes the proof of the theorem.

Proposition 4.1.5: Nagendram Γ-semi sub near-field spaces of a of a Γ-near-field space over near-field N have no small Γ-semi sub near-field spaces, i.e. if N is a Nagendram Γ-semi sub near-field space, then there exists a neighbourhood V of the identity so that for all $g \in V$ there exists a positive integer K depending on g having the property that $g^K \notin V$.

Proof: Recall that $(d \exp)_0 : g \to g$ is the identity. By the Inverse function theorem, there exists neighbourhoods V' of 0 in g and U' of $1 \in M$ so that $\exp : V' \to U'$ is a diffeomorphism. Let $U = \exp(1/2\, V')$. We claim that U is the desired neighbourhood.

If $g \in U$, then $g = \exp(1/2\, v)$ for some $v \in V'$. Then, $g^n = \exp(1/2v) \ldots . \exp(1/2v)$ (n times) for any positive integer n.

Now, given v, pick N so that $N/2\, v \in V' \setminus ½\, V'$. Then, $g^N \in \exp(V') \setminus \exp(1/2\, V') = U' \setminus U$. This completes the proof of the proposition.

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